JPRS 76497

25 September 1980

USSR Report

LIFE SCIENCES

EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

No. 2

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CONTENTS

BIOLOGICAL EFFECTS OF MAGNETIC FIELDS

Prague PRACOVNI LEKARSTVI in Czech Vol 31, No 3, 1979 pp 98-106

[Article by Jiri Jerabek, Institute of Hygiene and Epidemiology, Prague, Director: Prof. F. Janda, MD, ScD; Center for Labor Hygiene and Occupational Diseases; Director: B. Svestka, member of the Academy of Sciences]

[Text] Magnetic Field and Its Physical Substance

In the area surrounding conductors through which electric current flows, and in the area surrounding magnets, the so-called magnetic forces affect other conductors through which electric current flows, and other magnets. We regard transmission of such forces as physical properties of the magnetic field created in the area surrounding such conductors, or as the case may be, magnets.

In their essence, magnetic forces are electrodynamic forces, in other words, forces by which all electrically charged particles in motion affect one another. In addition to these forces bound to the motion of charged particles, electrostatic forces stemming directly from the presence of an electric charge act among them.

Every charged particle in motion creates a magnetic field, and thus, so do elementary particles of which atoms are composed. This magnetic field, however, becomes externally apparent only if the movements of the particles are at least partly ordered. If not, their magnetic fields on the average cancel one another and do not become externally evident.

Ordered movement of free charged particles proceeds in any medium through which electric current flows. The current creates magnetic field which develops by the combination of magnetic fields of individual free particles. Such a magnetic field develops, for instance, around a conductor through which electric current flows, around a beam of flying electrons in a cathode tube, around ions in an electrolytic bath, etc.

In addition, magnetic fields develop around electrons which are bound in atoms, namely, on the one hand, because the electrons move in orbits--the so-called orbital magnetic moment, and on the other hand, because they

rotate around their own axis--the so-called spin magnetic moment. If the movements of the electrons in atoms are at least partially ordered so that the magnetic fields of individual electrons do not cancel one another, a magnetic field develops by the combination of these magnetic fields in the substance as well as in the surrounding area, even if that substance is not connected with a source of electric voltage and if electric current does not flow through it in the technical sense of the word.

2. Types of Magnetic Fields

According to the course of the magnetic field in time we distinguish static, intermittent and pulsating magnetic fields.

The values of the basic quantity of a static magnetic field do not change in the course of time. This kind of field appears near permanent magnets or conductors and coils through which a direct electric current flows. In an intermittent magnetic field the values of the quantities of the magnetic field change in the course of time from zero to the positive maximum, decline to zero, and increase to the negative maximum, and then return to zero. This rise and ebb of the values proceeds smoothly. We find this type of field around conductors and coils fed by an alternating electric current.

The last type of magnetic field, the pulsating magnetic field, appears in the area of conductors and coils fed by a pulsating electric current. The intensity of values of this field changes from zero to the positive or negative maximum by spurts.

According to the spatial distribution of the magnetic field we distinguish homogenous and nonhomogenous magnetic fields.

In a homogenous magnetic field the values of the magnetic field have the same intensity and direction in every point in the space. We find this type of field inside a long cylindrical coil without a core--solenoid, as well as between parallel pole pieces of permanent magnets or electromagnets.

North and south poles are recognized in electromagnets and in magnets in the same way as in the geomagnetic field. This division stems from the tradition and consensus, according to the conduct of the compass needle. In the same way it has been agreed that the lines of force between north and south proceed in the north-to-south direction; the north pole is regarded as positive, and the south pole as negative.

The nonhomogenous magnetic field is one where in various points in the space the values of the magnetic field are found to be different in their intensity as well as in their direction. Such fields exist around the conductor through which electric current flows, around permanent magnets, at the edges of solenoids, and at the edges of pole pieces of magnets and electromagnets.

3. Expressions of the Magnetic Field

Effects of the magnetic field on objects made of iron are generally known. Such objects are attracted to a magnet or electromagnet by a certain force. However, numerous substances are macroscopically indifferent to the magnetic field, but the case is different on microscopic and submicroscopic levels. Substances are divided into diamagnetic, paramagnetic and ferromagnetic according to their conduct on those levels.

In diamagnetic substances the orbital and spin magnetic moments of the electrons in the same molecule cancel each other and thus, the resultant magnetic moment is zero. If the molecules of such substances contain one atom, this applies to their atoms as well.

In paramagnetic substances the magnetic moments of the electrons in molecules, or as the case may be, in atoms, do not cancel each other; however, magnetic moments of molecules are arranged quite haphazardly, so that their magnetic fields cancel each other and the resultant magnetic moment is zero.

In ferromagnetic substances, as in paramagnetic substances, magnetic moments in molecules, or in atoms, do not cancel each other, and furthermore, the molecules are arranged with a conforming orientation of the magnetic moments into bounded areas called Weiss' areas of spontaneous magnetization. If the external magnetic field does not act, these areas are oriented quite incidentally and without any arrangement, and the resultant magnetic moment is zero.

Diamagnetic and paramagnetic substances are magnetically polarized by the effect of the external magnetic field, i.e., they create their own magnetic fields, which are combined with the external magnetic field. After the dissipation of the external magnetic field magnetic polarization in these substances ceases.

If the external magnetic field affects a ferromagnetic substances, Weiss' areas of spontaneous magnetization expand and shift toward magnetic polarization, but after the dissipation of the external magnetic field this orientation is more or less retained, and we say that the substance has become magnetized.

4. Basic Quantities of the Magnetic Field

As a rule, we characterize the magnetic field by vectors called intensity of the magnetic field H and magnetic induction B. A certain dimension and direction of intensity H and induction B are inequivocally assigned to every point in the magnetic field.

Intensity of magnetic field H is in direct proportion to the flowing current and in indirect proportion to the distance.

$$H = \frac{I}{2\pi r}, \text{ where}$$

I represents the intensity of the electric current in amperes,
r is the distance from the current in meters.

The unit of intensity of the magnetic field is ampere/meter (A/m), which is defined as the intensity of the magnetic field in distance $r = 1/2\pi m$ from a conductor through which flows electric current of 1 ampere. An older unit, used frequently in literature, is 1 oersted (Oe). 1 Oe = 79.6 A/m; 1 A/m = $1.256.10^{-2}$ Oe. Induction of the magnetic field B is defined by the force by which the magnetic field affects the moving electric charge, or as the case may be, the conductor through which the electric current flows. The unit of induction of the magnetic field is 1 tesla (T). This unit is defined as follows: If a conductor 1 meter long, through which 1 A current flows, is affected in a homogenous magnetic field by the force of 1 N (newton), then the induction of that field equals 1 T. An older unit is 1 gauss (G). 1 G = 10^{-4}T; 1 T = 10^4 G.

The correlation between the induction of the magnetic field V and intensity of the magnetic field H is given by the following equation:

$$B = \mu \cdot H$$

μ is the permeability of the medium. Relation $\mu = \mu_r . \mu_o$ applies, where $_r$ is the relative permeability of the medium, and μ_o is the permeability of the vacuum. μ_o $1.256647.10^{-6}$ H/m (H = henry, unit of inductance).

Diamagnetic substances have μ_r under 1, paramagnetic substances have μ_r over 1, and ferromagnetic substances have μ_r much higher than 1; in diamagnetic and paramagnetic substances relative permeabilities differ very slightly from each other, and therefore, their permeability $\mu = \mu_o$.

5. Measurement of Magnetic Fields

Instruments furnished with Hall probe are now used in general to measure magnetic fields. Their principle is based on the concept that the current of electrons intersecting the lines of force is deviated, and that this deviation is in direct proportion to the induction of the magnetic field. This phenomenon is particularly noticeable in semiconductors. Hall probe is a plate made of a semiconductor material through which an electric current flows. If we place it in a magnetic field that will act perpendicularly to the current passing through the place, we can measure on its side the voltage which is in direct proportion to the induction of the magnetic field.

An instrument furnished with Hall probe is, for instance, TESLAMETER made by the Metra Company in Biansko; according to our information, however, it is no longer manufactured. This device is designated for rough measuring in laboratory conditions and according to our experience, it is not the most suitable instrument for measurements in the field because of its sensitivity to mechanical damages and because of its sensitivity to changes in temperature.

Measurements of intermittent magnetic fields may also be made with instruments furnished with Hall probe and with an appropriately adapted electronic part of the instrument. This kind of instrument is not available in our market. However, devices with a coil into which measurable voltage is induced may be used advantageously.

There are problems in measuring pulsating magnetic fields, where standard measuring methods with needle instruments fail because the pulses are usually so brief that the needle cannot follow the changes in the field due to its inertia at rest. The coil may be used here as a probe and records may be made on the oscillograph; the values of the magnetic field may be read from the record.

The following principles must be observed when measuring magnetic fields:

1. The values of induction or intensity of the magnetic field must be measured on the site of the source;

2. Measurements must be made in the site of work;

3. The surroundings of the source and of the work site must be surveyed and measured carefully because the iron parts of the equipment deform the field;

4. In certain cases it is necessary to draw a chart and in it, equipotential lines.

Furthermore, it is necessary to know how long is the exposition and what parts of the body are exposed and naturally, to mention whether a static, intermittent, or pulsating magnetic field is involved.

6. The Occurrence of Magnetic Fields

In this paper we shall disregard the magnetic field of our planet in which we find ourselves constantly. We shall observe magnetic fields which may appear in man's working area. For the sake of completeness I wish to mention that the magnetic field of the Earth is equal to 0.3 - 0.6 Oe (23.88 - 47.76 A/m). The vacillation of those values depends on cosmic influences, particularly on solar activity.

Static magnetic fields appear in manipulation with permanent magnets, for instance, in the manufacture and assembly of ferrite magnets for toys and models, manufacture of loudspeakers and microphones, manufacture of special electron tubes, gauging instruments, etc. In addition, static magnetic fields appear near conductors through which strong electric current flow, for example, during electrolytic processes, and finally, in electromagnets fed with direct current, as in magnetic cranes, with longitudinal magnetization with magnetic crack detection, in grinders with magnetic benches, etc.

Intermittent magnetic fields appear around conductors through which alternate electric currents flows, for instance, in electric steel works, in transverse magnetic crack detection, in induction heating systems, etc. We may find pulsating magnetic fields in spot welding, around electromagnets operating in a pulsating regime, as in some accelerators, in magnetization of permanent magnets, etc.

7. Biological Effects of Magnetic Fields

From the beginning of its journey toward knowledge mankind studied the effects of magnets on the living matter. Application of magnets belonged among general methods of healing already in ancient Greece, Rome and Arabia. Medieval Europe adopted such methods but they were discredited by itinerant healers and charlatans.

Genuine scientific research of the effects of magnetic fields on the living matter did not begin until the 19th century, when with the development of knowledge substantive discoveries were achieved in the areas of physics as well as of biology. For those reasons we shall deal further on only with those reports which in our opinion have a scientific basis.

Effects of magnetic fields have been studied experimentally on the most different levels, from a simple biochemical reaction through the effects on the subcellular level and on cells, up to whole vegetable, animal and human organisms.

7.1 Effect of Magnetic Fields on Microorganisms

This part is intentionally included in the beginning of the chapter on biological effects, although it would be more logical to quote studies dealing with biochemical reactions. In our view, however, these studies were among the first ones, as concerns the development of the research of the effects produced by magnetic fields, and therefore, they belong precisely here. There exists a relatively large amount of reports dealing with this topic, however, they are mutually contradictory and antagonistic. Dubois[15] studied the effect of a strong magnetic field on colonies of Micrococcus prodigiosus, observing morphological changes in those colonies. He noted that the colonies became elongated in the north-east/north-west direction.

Moreover, the colonies grew in a dry form with uneven edges. Cheneveau and Bohn[25] studied the effect of a static magnetic field of 5-8 kOe intensity (398-636.8 kA/m) on Infusoria Coxyphyllum maris, Copidium, Stylonichia, Oxytrichides, and Verticella. They observed deceleration of the mobility of the Ciliata and the dissolution of their organules of motion within 4 or 5 days. Within several generations the individuals atrophied and decreased to one half or one third of their original size. Finally, they completely stopped multiplying. In Vorticella all individuals died within 4 days.

Grenet[20] studied the effect of the intermittent magnetic field with more than 100 Oe (7960 A/m) intensity on Paramecium aurelia. As soon as in 30 minutes he observed deceleration and then cessation of its mobility. Most protozoa adopted a spherical form and in several of them their cellular membrane ruptured and the contents of the cell spilled out into the medium. Jennison[28] obtained negative results. Using 3 kOe (238.8 kA/m) static magnetic intensity he followed in that field the growth of cultures of 12 strains of bacteria and 13 strains of molds and yeasts. In no instance did he note any difference from the control group. Analogically, Luyet[39] failed to observe any difference in the spores and vegetative forms of Rhizosporus nigricans exposed to a 524 Oe (41.7 kA/m) field. Kimball[33] followed the process of the growth of bakery yeast under the poles of a horseshoe magnet. He established that the growth directly under the poles was considerably inhibited, and the farther from the pole, the less inhibited the growth. It appears that in Kimball's experiments this effect was produced by the gradient of the magnetic field. Several series of studies deal with fermentative changes and with changes in oxygen consumption of various cultures. Gaule[19] reports a higher fermentative potential of yeasts following their exposure to a static magnetic field. Pereira et al.[48] determined that in a strong magnetic field (10 kOe - 796 kA/m) the oxygen consumption of the yeast declined, that this decline begins immediately after the magnet is turned on, and that it is reversible. Pavlovich et al.[46] passed various strains of microorganisms through fields of various intensities and types. They followed the effects of these fields on enzymatic and lysogenic systems, and on thermoresistance. They determined that the effect depends not only on the type but also on the strains and mutants of individual microorganisms, and naturally, also on the type of the field to which individual cultures are exposed.

7.2 Influence on Biochemical Reactions and Tissue Oxidations in Vitro

Cook and Smith[9] observed that the activity of trypsin exposed to a static magnetic fields with 8 and 14 kOe (636.8 and 1034.4 kA/m) intensities increased. This increase depended on the period of pre-incubation of the enzyme in the magnetic field. Akoyunoglou[3] found that the activity of carboxy dismutase after exposures for 1-196 hours in a static magnetic field of 20 kOe (1593 kA/m) had increased by 14 to 20 percent. After a

22-minute exposure no effect was evident. It was noted that activity increased instantaneously when the electromagnet was turned on during the reaction; when switched off, the activity of the enzyme rapidly declined. Furthermore, the author observed an advantageous reactivating effect of the magnetic field on an enzyme partially inhibited by UV radiation. Haberditzl[24] conducted experiments with catalase, using a static magnetic field of 60 kOe (4776 kA/m) intensity, with 17-60 minute exposure periods. No effect was observed when the reaction took place in a homogenous field. When the author used a nonhomogenous field, the activity of the catalase increased by 52 percent. Contrary to the above-mentioned studies, Rabinovich et al.[53,54] did not observe any effect of a static magnetic field of 208 kOe (16,556.8 kA/m) intensity on reactins catalyzed by ribonuclease, peroxidase, thyrosinase, succinate-C reductase and aldolase. In addition to biochemical experiments on the enzyme-substrate level, experiments have been conducted in cells of tissue cultures. Reno and Nutini[55] studied the consumption of O_2 in cultures of tissues from sarcoma 37 and Ehrlich's tumor which they exposed in a static magnetic field of 7.4 kOe (581.08 kA/m) intensity. Oxygen consumption decline by [illegible] percent in sarcoma and by 33.7 percent in Ehrlich's tumor. When ascertaining the threshold intensity, the authors learned that, on the contrary, the consumption of oxygen increased in a field with 80 Oe (6,386 kA/m) intensity, that it declined only at 400 Oe (31.84 kA/m) intensity, and that this ratio remains linear up to the intensity of 7.3 kOe (581.08 kA/m). On the other hand, Pereira et al.[48] who studied tissue respiration of an exposed suspension of sarcoma 37 and of sections from the kidneys and livers of mouse embryos obtained opposite results. They observed that cellular respiration declined in every case exposed to a static magnetic field of intensity in the range from 80 to 85 Oe (6,368-6,766 kA/m). It is interesting that the tissue sections from adult mice may not be sensitive to the magnetic field because they did not demonstrate any visible effect.

7.3 Effect on Biochemical Processes in Vivo

Reno and Nutini[55] determined that after an exposure to a static magnetic field with an intensity of 7.3 kOe (581.08 kA/m) oxygen consumption in mice embryos is reduced by as much as 67.2 percent. It was ascertained that the younger the embryo, the more pronounced this phenomenon. Chernysheva and Kolodub[10] exposed rats to an intermittent magnetic field with the intensity of 90 Oe (7,164 kA/m) and 50 Hz frequency over different periods. They studied the levels of lactic acid, glucose, glycogen, creatine phosphate, ammonia, protein nitrogen, and desoxyribonucleic acid in the brain, liver, cardiac muscle and kidneys. After an exposure over 10 days, each day for 5 and 3 hours, they observed that the level of glycogen in the liver declined and the contents of glycogen and glutamine in cardiac muscles increased. After an exposure for 5 and 3 hours every day over 3 months, the changes were analogical as in the preceding case and moreover, the authors observed a decline in the contents of lactic acid in

the brain and higher contents of ammonia in the brain and in the cardiac muscle.

The results of a 6-months exposure for 3 and 5 hours are presented in Table 1.

Table 1

	Lactic Acid	Glucose	Glycogen	Ammonia	Glutamine	Protein SH	RNA	DNA
Brain	-	///	-	+	+	+	-	+
Liver	-	-	-	+	-	+	+	+
Heart	+	-	-	+	+	///	///	///
Kidneys	-	+	///	-	+	+	///	///

- = decline, + = increase, /// = not determined

Lower contents of creatine phosphate were detected in cerebral tissues. Degeneration of hepatocytes was histologically confirmed in hepatic tissues. Higher contents of catecholamines in adrenal glands was observed. One month after the conclusion of exposure, all values returned to normal, with the exception of catecholamine contents in adrenal glands.

Udintsev et al.[62] exposed mice in an intermittent magnetic field of 200 Oe (15.92 kA/m) intensity and 50 Hz frequency over a period of 1 hour, and studied the activity of lactate dehydrogenase in their skeletal and cardiac muscles. In both cases the activity of the enzyme under study was found to be significantly reduced.

7.4 Effect of the Magnetic Field on Infectious Diseases and Immunity in Animals

Odintsov[65] proved that repeated exposures of rats to an intermittent field with 50 Hz frequency and 100 Oe (7.96 kA/m) intensity for 6.5 hours reduced LD_{50} in Listeria infection to 1/50 as compared with the control group. The phagocytic activity of leukocytes was three times lower and remained

reduced 7.5 times even on the 28th day after the exposure had ended. Vasiliev[65] obtained similar results with the infection of the tick encephalitis virus. Savenko[56] ascertained that the phagocytic activity of leukocytes declines in rabbits exposed to a static magnetic field of 2 kOe (159.2 kA/m) and to a pulsating magnetic field with the intensity of 5 kOe (398 kA/m) for 6 days, with daily exposures lasting 10-15 minutes. On the other hand, Tomas et al.[61] found that the phagocytic activity of leukocytes in dogs' blood increased by 71.8 percent when exposed for 30 minutes in a static magnetic field with the intensity of 700 Oe (55.72 kA/m). Jitariu[29] detected an increased production of antigens against sheep erythrocytes, Proteus OX_{19}, and of [illegible] in rabbits and guinea pigs he had exposed to a static magnetic field with the intensity of 300 Oe (23.88 kA/m) over 15 days, with daily exposures of [illegible] minutes. On the other hand, Gross and Smith[21] observed a reduced production of antigens in mice immunized by sheep erythrocytes and exposed to a static magnetic field of 4 kOe (318.4 kA/m) intensity.

They did not observe any effect in immunization with other antigens. Vasiliev et al.[66] obtained interesting results in their study of the dynamics in the production of antigens in mice immunized with sheep erythrocytes after a single exposure to an intermittent magnetic field with the intensity of 200 Oe (15.92 kA/m) at 50 Hz frequency, lasting 6 to 7 hours. The experiment was conducted so as to expose the animals either immediately before their immunization or at an early stage of their antigen production, or in a late stage of their antigen production. In the first case, the antigen titre was lower, in the second case higher, and in the third case it did not differ from the control.

7.5 Effect of Magnetic Fields on the Nervous System

From the very beginning of the research of effects of magnetic fields on biological subjects the attention of the researchers focused on potential changes in the function of the peripheral as well as central nervous systems.

D'Arsonval[11] described the perception of light in persons whose heads had been exposed to an intermittent magnetic field with frequency from 10 to 100 Hz. This magnetophosphene occurred with the intensity of 400 Oe (31.84 kA/m) at the optimum frequency of 20-30 Hz.

In addition to phosphenes, other authors described altered optical perception. Mogendovich and Skachedub[41] reported reduced optical acuity in persons exposed to a magnetic field. A permanent magnet placed on the nape changed optical, hypnotically-induced perception[44] and amplified mescaline-induced hallucinations.[49] Studies of mobility in birds found it to increase in a field of 1 Oe (79.6 A/m).

Data in literature further indicate that the magnetic field reduced the response to light stimulation in amphibians[6] and in humans.[66] Lower phagocytic activity of the leucocytes,[27] increased Hb rate, and deceleration of erythrocytic sedimentation[7] were observed in a magnetic field locally applied to the heads of animals. The results of experiments with training in a labyrinth conducted under the effect of magnetic fields indicate that this factor curbs the creation of memory tracks, and accelerates their extinction.[5,47] Naturally, Polyhe's observation should be mentioned here, namely, that there is no difference between the effect of magnetic fields with intensities of 10 Oe (796 A/m) and 800 Oe (63.68 kA/m).

Electroencephalographic tests indicate that in pigeons,[23] rabbits, 26, 27 monkeys,[34] and humans,[12,67] the magnetic field stimulates the appearance of slow waves with a high amplitude and the formation of spindles on the EEG. Vialov reported results obtained in workers employed in operations involving magnetic fields (details below). Dinculescu and Macalariu in the Socialist Republic of Romania studied EEG in individuals treated with Magnetodiaflux. Unfortunately, more detailed descriptions of the equipment protected by a patent are lacking in the literature; the only information available is that it involves an intermittent magnetic field with 50 or 100 Hz frequency, and that the patient reclines in the cavity of a solenoid fed with an electric current in the vicinity of an unspecified intensity from the electronic part of the equipment.

7.6 Effect of the Magnetic Field on Workers in Operations Exposed to Magnetic Field

Vialov[67] studied for several years the condition of health of workers employed in engineering plants, in whose operation magnetic fields appear. Those were factories manufacturing magnets, where technicians-inspectors and sinterers were observed during the process of production, and plants where flaws are magnetically detected and where grinders with magnetic benches are in operation. Because this involves the hitherto most detailed investigation found in the literature, and because it presents an excellent demonstration of various methods of investigation applied and on interpretation of results, the contents of Vialov's study are presented here in detail (Tables 2, 3).

Table 2. Number of persons in individual jobs, with regards to the period of their employment and sex (the tested group was in the age range from 19 to 40 years).

Occupation	Period of Employment				
	less than three years		more than three years		Total
	male	female	male	female	
Inspectors	56	66	41	45	208
Flaw detectors	57	63	61	60	241
Sinterers	26	30	12	16	184
Grinders	34	11	59	8	112
Total	173	170	173	129	645

The gradient of the field was measured at 5-20 Oe (398 A/m-1592 A/m/cm), from which it follows that at a distance from the source equal to 0.5 to 1.5 m the field was on the level of the background. The intensities of an intermittent magnetic field did not exceed 1 kOe (79.6 kA/m) at 50 Hz frequency; the intensities of the pulsating magnetic field did not exceed 50 Oe (3.98 kA/m) on the hands, and 5 Oe 398 A/m) on the head and chest. Workers in engineering factories who served as control group had not been exposed to the magnetic field. This group consisted of 138 individuals, of whom 70 persons (33 male and 37 female) had been employed there for more than 3 years.

According to the results of the examination the author reports two leading syndromes: peripheral vasovegetative, and asthenovegetative. He emphasizes in particular the functional vascular and cardiovascular changes. The peripheral vasovegetative syndrome occurred in the form of vegetative, trophic, and sensitive changes with less pronounced motor changes, and changes of reflexes, localized in the distal parts of the upper extremities, i.e., in hands and in the lower third of the forearm. Initially, the changes on the hands were functional, with marked dynamism depending on the time of the examination, in other words, whether it took place at the beginning or at the end of the shift. These changes became permanent after 3 to 5 years on the job and their tendency was progressive.

The author found such changes in 18-41 percent of cases in all groups according to the intensity of the magnetic field. They involved vasodilation of the small arteries, capillaries and veins. The arteries were the first ones to become affected, the arterial segment of the capillary vessels was the next, then the venal segment of the capillary vessels, and finally, the small veins.

Initial symptoms appeared in the form of changes of the skin on the palms which turned pink. Their original color returned 1 to 3 hours after the end of the shift. If the work continued for more than one year, the color of the skin turned bluish-pink, and remained so even during the period of

Table 3. Intensities of static magnetic fields in individual occupations

	Maximum intensity on the level of:		Most frequent intensity (in 80 percent) on the level of:	
	Hands	Body	Hands	Body
Inspectors - electro-magnets	1000-5000 Oe 79.6-398 kA/m	300-750 Oe 23,429-59.7 kA/m	50-900 Oe 3.98-71.64 kA/m	15-250 Oe 1.194-19.9 kA/m
Inspectors - permanent magnets	1000-5000 Oe 79.6-398 kA/m	30-150 Oe 2.288-11.94 kA/m	100-550 Oe 7.96-43.78 kA/m	13-70 Oe 1.034-5.572 kA/m
Sinterers - electro-magnets	150-360 Oe 11.94-28,656 kA/m	60-80 Oe 4.776-6,368 kA/m	24-150 Oe 1.91-11.99 kA/m	16-150 Oe 1.274-11.94 kA/m
Sinterers - permanent magnets	1000-5000 Oe 79.6-398 kA/m	70-180 Oe 5.572-14,328 kA/m	100-560 Oe 7.96-44,576 kA/m	10-50 Oe 0.796-3.98 kA/m
Flaw detectors - electro-magnets	300-900 Oe 23.88-71.64 kA/m	50-150 Oe 3.98-11.94 kA/m	120-460 Oe 9.552-36.616 kA/m	18-110 Oe 1.432-8.756 kA/m
Flaw detectors - permanent magnets	270-850 Oe 21.429-67.66 kA/m	30-150 Oe 2.388-11.94 kA/m	50-160 Oe 3.98-12.736 kA/m	12-60 Oe 0.955-4.776 kA/m
Grinders - electromag. benches	400-700 Oe 31.84-55.72 kA/m	75-100 Oe 5.97-7.96 kA/m	50-180 Oe 3.98-7.96 kA/m	10-50 Oe 0.796-3.98 kA/m
Grinders - permanent mag. benches	250-700 Oe 19.9-55.72 kA/m	30-150 Oe 2.388-11.94 kA/m	50-160 Oe 3.98-12.736 kA/m	15-70 Oe 1.194-5.5[illegible] kA/m

feet. The author reports livid coloration of the skin on the palms after more than 3-5 years. He observed very frequent cases of cyanosis, especially in pendent upper extremities.

Capillaroscopy demonstrated coiled, elongated capillaries with an extended venous network. In addition, the author established that the temperature of the hands was elevated, and the forearm-hand thermal gradient inverted by 1-1.5°C; furthermore, thermal asymmetry of the hands equal to ±0.4°C was evident in 17-20 percent of the cases, while an analogical observation was made in only 8 percent of the control group. These changes were more prominent toward the end of the shift and in workers who had been on the job for more than 3 years.

Along with a higher temperature of the hands, profuse perspiration of the palms was evident, frequently sweat trickled in rivulets. The skin on the palms of some individuals remained dry throughout the entire shift. In connection with the perspiration skin resistance declined. In experiments with intradermal application of adrenaline and histamine in the lower third of the forearm, it was determined that the reaction to adrenaline was inhibited, while the response to histamine was increased.

Hyperesthesia of the skin on the hands and forearms appeared in workers with 1-3 months on the job, and with an increasing period of employment it changed into hypesthesia which became pronounced after 1-2 years. Trophic changes appeared on the hands of workers with 3-5 years on the job. Their skin and dermis were infiltrated and pasty. In those cases there appeared a 1-2.5 cm difference in the cross circumference of the hand at the beginning and at the end of the shift. Hyperkeratosis, or on the contrary, thinning of the skin up to the disappearance of the skin relief appeared on the palms. Longitudinal striation, brittleness and malformation of the nails became evident. Pain threshold was raised, the pilomotor reflex was either lower or completely absent.

Among the motor changes, reduction of the muscular tonus in the hand and forearm, and reduction of muscular strength, particularly in digital flexors, were evident. The muscles of the hands were found to be atrophied in some of the cases. In addition to the effect on the hands and forearms, general symptoms of exposure to the magnetic field appear in the form of the asthenovegetative syndrome. This concept is characterized by general functional disturbances, the principal among which is an impairment of the vegetative innervation of the heart and capillaries. Subjectively, the workers complained of headaches, periodically occurring vertigo, buzzing in their ears, and unclear, blurred vision. The tested individuals felt irritated, impatient, restless, and experienced pains in the area of the heart. Objectively, duller cardiac sounds, reduced QRS voltage on the ECG, elongated electrosystoles (by 0.1 and more), and slightly lower or higher T wave were detected. Bradycardia was diagnosed in 5-43 percent of the

cases, tachycardia in 22-37 percent of the cases, tendency toward arterial hypotension in 34-43 percent of those examined.

In workers who were 2-3 years on the job blood pressure tests determined systolic pressure lower by 10-18 mmHg, diastolic pressure lower by 4-8 mmHg as compared with the values ascertained in initial examinations. The occurrence of hypertension was in reverse relation to the intensity of the magnetic field.

Red dermographism spreading over the area and frequently turning white was observed in 60-80 percent of the cases of mechanical irritation of the skin on the chest for the tests of the response of skin capillaries. Perspiration increased in 58-82 percent, particularly in the face, in the axillae, and in women also on the chest and lower abdomen. Subjectively, changes of appetite were evident, with an increase in 4-23 percent, and a decline in 10-15 percent; pains in the epigastrium and in other parts of the abdominal area, in women particularly in the area of the gall bladder projection were reported. Tendency to constipation up to constipation, appeared in 21-37 percent of the cases. Moreover, slight, frequent tremors of the hands, tongue and eyelids were observed. The tendon and periostel reflexes were livelier, enhanced, polykinetic, with extended reflexogenic zones. The workers complained of general weakness, pains in their muscles, joints, long bones and spine, and furthermore, of paresthesia between their shoulder blades and in their hands.

In terms of mental activity, disturbed perception, inability to concentrate, and disturbances of memory were observed. The author describes certain "magnetophobia," i.e., a tendency to hypochondria and aggravation especially of visceral complaints.

Changes objectively diagnosed by means of EEG were of the following three types:

1. Short-term aggravation of desynchronosis;
2. A higher rate of alpha waves and a reduced response to photostimulation;
3. A higher rate of slow waves and a reduced response to photostimulation.

The first type was observed in flaw detectors, the first and second types in inspectors, the second and third types in sinterers. Objectively, changes in biochemical values have also been observed. A higher level of gamma-globulin was established, particularly in the first 3 years on the job; moreover, lower contents of nucleic acids and oxidase were found in the peripheral blood. Hematological tests established leukopenia with a normal leukogram, and lumpho- and monocytoses were evident with a normal rate of the leukocytes. Erythrocyte sedimentation was retarded to less than 8 mm/hour.

In view of the fact that in addition to magnetic fields, some other factors appearing in the conditions of industrial operations may induce various physiological changes, the author conducted an experiment with a group of healthy 21-23 year old male subjects. The participants in the experiment lay on a bed, with their right hands placed in the crevice of an electromagnet with the intensity of the statis magnetic field equal to 1 kOe (79.6 kA/m). The period of exposure was 15 minutes. The ECG, the temperature of the hand, and the blood pressure were measured immediately after turning off the electromagnet, and 1, 5, 15, and 30 minutes after the end of the exposure. Blood was drawn from a finger and from a vein 15 minutes after the beginning of the experiment, and the values of total calcium, ionized calcium, natrium, and chlorine were established. In addition, the threshold of pain in the hand was tested and the resultant values were statistically processed.

In the ECG, the T wave was extended by 0.03 s (statistical significance $p = 0.05$), the temperature of the hand was 2°C higher ($p = 0.02$), blood pressure 6 mmHg lower ($p = 0.05$), pain threshold was up ($p = 0.1$). The biochemical indicators confirmed that the level of total calcium increased by 0.25 mg percent ($p = 0.02$), the level of ionized calcium declined by 0.5 mg percent ($p = 0.02$), the natrium level declined by 16 mg percent ($p = 0.02$), and the chlorine level declined by 22 mg percent ($p = 0.02$). All indicators reached their peak in the 1-15th minute after the end of the exposure, and returned to normal within 30 minutes. On the basis of the tests in industrial plants, examination of workers, and experiments, the author recommends that the maximum intensities of magnetic fields for the exposure of the hands equal to 700 Oe (55.72 kA/m), and of other parts of the body to 300 Oe (23.88 kA/m).

Beischer and Reno[31] in the USA recommend exposure ceilings which are presented in Table 4.

Table 4

Period of exposure	Exposed parts of the body	Induction of the field (G)
Long-term (hours)	Whole body or head	200
	arms and hands	2000
Short-term (minutes)	Whole body or head	2000
	arms and hands	20000

Soviet standards set by the Ministry of Public Health of the USSR for static magnetic fields permit the highest intensity of magnetic fields equal to 8 kA/m = 100 Oe, no matter what part of the body is exposed and for how long.[68]

7.7 Theory and Hypotheses Concerning the Mechanism of the Effect of Magnetic Fields on Biological Subjects

These theories and hypotheses may be divided into several groups:

1. Effect on the molecular level;
2. Effect on the subcellular level;
3. Effect on the flow of fluids;
4. Induction of the electromotor force into the nerve.

Blumenfeld,[8] and Mueller et al.[42] presume that ferromagnetic molecules existing in biological systems may be oriented according to the effect of the external magnetic field. Naturally, Abatin and Evtushenko[1] deny this possibility because in biological systems there are no substances with such structures that they could constitute Weiss' areas of spontaneous magnetization. In his hypothesis Lansheven[36] presumes the possibility of orienting small molecules in magnetic fields, but this effect is negligible as compared with the thermal flow.

As for paramagnetic molecules in biological systems, Abatin and Evtushenko contend that the effect of electric forces (coulomb and Van der Waals forces), which is substantially more powerful, overcomes the effect of the magnetic field.

However, according to Dorfman[13, 14] large anisotropic diamagnetic molecules with molecular weight over 10^6 may be oriented in a homogenous magnetic field; in a nonhomogenous magnetic field they may even create a gradient of concentration. Nevertheless, Abatin and Evtushenko[1] deny even this view, because in their opinion even here thermal energy is far higher than the energy of the magnetic field.

Abatin and Evtushenko also criticize Gross and Valentinuzzi[22, 63] who declared that the magnetic field may affect, and change, the valence angle by the change of the spin moment. The Soviet authors base their criticism on experiments conducted by Maling et al.,[40] where the field of induction equal to 50 kG (5 T) did not affect the activity of ribonuclease and succinate-cytochrome reductase, and on experiments conducted by other authors (see above) who never proved the effect of strong magnetic fields on the kinetics of enzymatic reactions. Positive results reported by other authors, however, call for an explanation.

It seems that the role of the water is not neglig ble in the action of magnetic fields on biological systems. It is known that certain physical-chemical properties of water change when it flows through a magnetic field. This phenomenon is applied, for instance, in the processes of water treatment in water works, because it has been determined that tiny, regular crystals of dissolved salts which are formed under the effect of the magnetic field flow away in the form of sludge, which substantially reduces the growth of boiler scale.

This phenomenon inspired certain authors to use magnetically treated water in order to suppress the deposit of concrements.[43] Piccardi[51] even explains the effects of magnetic fields solely by water and water systems, with the hypothesis that the magnetic field can affect their structural arrangement in all consequences. Thus far, no unequivocal proof of this theory has been available.

Nevertheless, it seems that magnetically treated water is biologically active, as confirmed by the experiments conducted by Stefanov and Solakova[57] where experimental mice were given magnetically treated water in which the biochemical values had been shifted.

An important factor for the effect of magnetic fields appears to be the reaction of biological membranes. Experiments conducted by Shishlo and Shimkevich[59] dealt with the activity of mitochondrial enzymes in the liver of white mice as compared with the cytoplasmic enzyme; these experiments indicate that increased activity of mitochondrial enzymes depends on the permeability of the mitochondrial membrane.

Analogically, Petz's[50] experiments with osmotic resistance of erythrocytes, which decreased after an exposure of the blood in a static magnetic field of 200 G (0.02 T) indicate a change in the condition of the cellular membrane. In his comprehensive report on the effects exerted by magnetic fields on tumors, Kim[32] presumes potential depolarization, increased permeability, and deformation of biological membranes. Considerations of depolarization fully agree with experiments conducted by Kogan et al.[35] who measured the membrane potential of the Nitella flexis cells, nerve cells of the crayfish, and isolated hearts of cold-blooded animals after an exposure in magnetic fields. A marked decline was observed in every instance.

The velocity of the flow of fluids in a magnetic field is expressed by Hartmann's equation:

$$M = \frac{a \cdot H}{c} \sqrt{\frac{\sigma}{\eta}}$$

where H = intensity of the field in Oe; c = velocity of light; σ = electric conductivity; η = coefficient of viscosity; a = radius of the duct through which the liquid flows. Deceleration at $M = 1$ is evident.

This equation is generally valid and thus, it also applies to the flow of the blood in capillaries. If the diameter of the capillary is 20 mm, at $\eta = 10^{-2}$ and $\sigma = 2.10^{2}$ for blood, $M = 1$ is valid at the intensity of the field whose vector is perpendicular to the longitudinal axis of the capillary 2.10^{6} Oe ($179.2 \cdot 10^{6}$ A/m).

According to calculations made by Belousova[7] for the deceleration of the rate of the flow of blood in the aorta (Δ v/v) under the influence of the magnetic field, it applies:

H (Oe)	Δ v/v (percent)
$2.\ 10^3$	0.1
$2.\ 10^4$	9.0
$2.\ 10^5$	55.0
$2.\ 10^6$	94.0

from which it follows that a field with $H = 2.\ 10^4$ Oe may already affect the hemodynamics in the aorta.

With regard to the effect on the transfer of nervous stimulus, Dorfman considers that the nerve acts as a conductor through which the electric current flows.[14] If such a conductor is located in a magnetic field, then according to Ampere's law it is affected by a force which causes its movement. Dorfman presumes that in case of air passing along the nerve, the nerve bends according to the intensity of the field up to several hundred microns. Returning to its original position, the nerve is induced with electromotor force of the vector opposite to that of the passing stimulus. If after the first stimulus another stimulus soon follows, the second stimulus is affected by the induced electromotor force. The author explains by this mechanism the appearance of the slow wave in the EEG.

Abatin and Evtushenko[2] who subjected this hypothesis to criticism proved mathematically that the induced current is lower by approximately 8 orders than the current flowing through the nerve during the passage of the stimulus. From that they conclude that Dorfman's hypothesis is incorrect.

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Submitted for publication on 1 September 1977.

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UDC 576.7:576.353:591.044.9

TISSUE SPECIFICITY IN THE EFFECTS OF STRONG MAGNETIC FIELDS ON THE MITOTIC INDEX

Leningrad TSITOLOGIYA in Russian No 2, 1980 pp 205-209

STRZHIZHOVSKIY, A. D., GALAKTIONOVA, G. V., and CHEREMNYKH, P. A., Institute of Biomedical Problems, USSR Ministry of Health, Moscow

[Abstract] In order to investigate the effects of strong magnetic fields on mammalian cells, mice were exposed to 2.9 kOe (0.3 kOe/cm) - 127.0 kOe (3.0 kOe/cm) infralow frequency magnetic fields for 1 h with subsequent determinations of the viability, mitotic index, and chromosomal structures of the bone marrow cells and the epithelial cells of the cornea and the intestinal tract. The mitotic index of corneal epithelium decreased during exposure, recovered to background levels by day 1, exceeded the background level twofold by day 2, and returned to essentially control values by day 3. Depression of the mitotic index was directly proportional to magnetic field strength. Bone marrow cells presented with dose-related depression of the mitotic index by day 1 and recovery by day 3, while intestinal epithelium remained unaffected by such exposures. The intensities of the magnetic fields employed in this study did not induce chromosomal aberrations. Depression of cell counts (20-25%) was of relatively short duration. Tables 1; references 9: 4 Russian, 5 Western.
[291-12172]

UDC 577.23

INFLUENCE OF MAGNETIC POLES ON THE ERYTHROCYTE SEDIMENTATION REACTION

Yerevan BIOLOGICHESKIY ZHURNAL ARMENII in Russian Vol 32, No 8, Aug 79 pp 782-785 manuscript received 30 Oct 78

VARDANYAN, V. A., RAPYAN, Yu. A., DZHINGOZYAN, A. K., TONOYAN, G. A., ASRYAN, N. V. and PLUZYAN, M. A., Yerevan Medical Institute

[Abstract] This article reports efforts to provide experimental data in support of the suggestion (Bardanyan, 1974) that blood is a ferromagnetic liquid and that the erythrocytes are the domain of the ferromagnetism. The work to enquire into the presence in erythrocytes of a magnetic moment deals with the effect of a magnetic field on the erythrocyte sedimentation rate (ESR). This work was done in two series--in 1972-74 and 1974-75. The field used was a nonuniform magnetic field formed between the poles of a permanent magnet. Nonuniformity was produced by special M-shaped caps on the poles. Minimum and maximum values of voltage were equal to 150 and 400 Oe. Distance between poles was 17.5 cm; average field gradient over 14.5 Oe/cm. Three blood samples in Panchenkov blood tubes were placed in the field; three controls outside it. ESR values were measured hourly for 24 hours. Data presented indicate that the nonuniform field does affect the ESR; strengthening on the field above, vertically, slows down the ESR; strengthening it below, speeds it up. This is attributed to the magnetic dipole behavior of the erythrocytes in the magnetic field. Magnetic moment values of individual erythrocytes can be estimated. References 6: Russian. [142-8586]

UDC 616.853-092.6-082.849.11

EFFECT OF A MODULATED ELECTROMAGNETIC FIELD ON EXPERIMENTALLY IND[illegible] EPILEPTIFORM ACTIVITY OF THE BRAIN IN THE RAT

Moscow BYULLETEN' EKSPERIMENTAL'NOY BIOLOGII I MEDITSINY in Russian No 2, 1980 pp 145-148 manuscript received 19 Mar 79

ANTIMONIY, G. D. and SAL[illegible]V, R. A., Moscow, Laboratory of Emotions and Emotional Stress, Institute of Normal Physiology imeni P. K. Anokhin, USSR Academy of Medical Sciences

[Abstract] The possibility of suppressing experimentally induced epileptiform activity of cerebral structures by means of a modulated electromagnetic field (MEMF) was investigated in experiments on 58 white rats in whom acoustic stimulation caused turbulent motor responses (inadequate running, jumping) often culminating in tonic or clonic-tonic convulsive fits. Persistent epileptiform activity was induced in the animals by applying brief electrical stimulation of limbic structures of the brain (hippocampus, tonsil) directly before applying the acoustic stimulus. The effect of MEMF was investigated against the background of distinct epileptiform activity on EEG. The MEMF parameters were as follows: carrier frequency 40 MHz, field intensity 10-20 v/m, modulation depth 80-100%, modulating frequencies 2-30 Hz. The MEMF was applied for from 5 to 60 min. MEMF was found to suppress epileptiform activity completely in 41.6% of cases, markedly in 23.3%, slightly in 25%, and not at all in 10.1%. Thus, MEMF produces a distinct antiepileptic effect on electroencephalographic manifestations of audiogenous epilepsy in rats. Figure 1; references 4: Russian.
[248-1386]

UDC 591.86:591.465.1]:612.014.481

ULTRASTRUCTURE OF SKELETAL MUSCULAR TISSUE OF CHICK EMBRYOS EXPOSED TO MICROWAVE DAMAGE

Leningrad ARKHIV ANATOMII GISTOLOGII I EMBRIOLOGII in Russian Vol 78, No 1, Jan 80 pp 83-88 manuscript received 16 May 79

DANILOV, R. K., Chair of Histology, Kuybyshev Medical Institute imeni D. I. Ul'yanov

[Abstract] The effects of ultrahigh frequency (UHF) of a low intensity (10 w/cm^2) on the ultrastructure of skeletal muscular tissue of developing chick embryos are reported. Limited cellular destruction and structural disorders are noted in muscle cell organelles. Along with the destruction, reactive-recovery processes take place on the intracellular and cellular tissue levels. These processes are expressed by hyperlasia and hypertrophy of organelles, activation of protein synthesis and increased number of developing muscle cells. Reparative processes are improved and the nuclear-cytoplasmic ratio is increased. Decreased rate of protein accumulation and lower quantitative indices for peripheral mitochondria manifest the depression of intracellular processes which may be due to incomplete development of the vascular system and poor supply of oxygen to muscle cells. The quantitative changes in the muscle cell organelles and the degree of their destruction depend on the differentiation of the muscular tissue, on the blood supply and on innervation of the muscle. Figures 2; references 15: 9 Russian, 6 Western.
[252-7813]

UDC 615.847.8:591.415+532.66

MAGNETIC FIELD EFFECTS ON MICROCIRCULATION

Minsk ZDRAVOOKHRANENIYE BELORUSSII in Russian No 12, 1979 pp 3-5

DEMETSKIY, A. M., SURGANOVA, S. F., POPOVA, L. I., and GAVRILOVICH, P. F., Chair of Operative Surgery with Topographical Anatomy, and Chair of Oncology with Medical Roentgenology and Radiology, Vitebsk Medical Institute

[Abstract] Microscopic, radiologic, rheologic, and radioisotope measurements were employed in evaluating the effects of constant magnetic fields (MF) on microcirculation in rat, rabbit, and dog extremities. The results showed that a single 10 min exposure to a 10, 50, 100, or 200 oe MF was followed within 5 min by capillary stasis and aggregation of the formed elements of the blood. During the next 5-10 min a variable pattern of stasis and accelerated blood flow prevailed in the precapillaries, capillaries, and arterioles. This phase was replaced by one characterized by vasodilatation, enhanced blood flow, and disaggregation (10-30 min), and a normal microcirculatory pattern the next day. Exposure for 7 days (10 min per day) yielded a similar but a much more pronounced triphasic patter of longer duration. One day after the course of exposures the blood flow was three-fold greater than after a single exposure; during the following 3-7 days the circulation gradually returned to normal. In each situation the magnitude of the observed effects was directly related to the strength of the MF. Figures 2; references: 1 Russian.
[170-12172]

UDC 616-092:591.149.1

CHANGES IN OXYGEN TENSION, TEMPERATURE AND BLOOD FLOW VELOCITY IN ANIMAL RENAL TISSUES DURING IRRADIATION WITH LOW INTENSITY ELECTRO-MAGNETIC WAVES IN THE ULTRAHIGH FREQUENCY RANGE

Kiev VRACHEBNOYE DELO in Russian No 11, 1979 pp 110-111

ERIN', A. N., Laboratory of Biological-Genetic Studies, Kiev Scientific Research Institute of General and Communal Hygiene imeni A. N. Marzeyev

[Abstract] Adult white rats were exposed to 2375 MHz, 50 uV/cm^2 radiation 7 hours per day for ten days, or 500 uV/cm^2 one or ten days at seven hours per day. The lower energy density exposure was accompanied by increased pO_2 of 23.2%, while the singly higher energy density exposure increased pO_2 83.2% and the repeated higher energy density exposure increased it by 75.2%. No change in renal blood flow rate was seen, except in hypoxia, where flow was less decreased and returned to normal more quickly in the irradiated rats than in controls. Intratissue temperature decreased 1.8° after the low energy density exposure, increased 0.8° after the single high energy density course and decreased 1.1° after repeated high energy density exposure. The data indicate definite adaptation and increased resistance of the organism to the effects of repeated ultrahigh frequency radiation. [233-12,126]

UDC 612.833.81.014.424.5

CHANGES IN CONDITIONED-REFLEX ACTIVITY OF RATS AS A FUNCTION OF THE INTENSITY AND DURATION OF MICROWAVE IRRADIATION

Moscow GIGIYENA TRUDA I PROFESSIONAL'NYYE ZABOLEVANIYA in Russian No 12, 1979 pp 30-34 manuscript received 17 Aug 79

LOBANOVA, Ye. A., Moscow, Institute of Hygiene of Labor and Occupational Diseases, USSR Academy of Medical Sciences

[Abstract] The functional state of the central nervous system (CNS) of white rats exposed to single and chronic (for up to 4 1/2 months) decimeter-range microwaves (1-10 mwatt/cm^2, daily exposure for from 15 to 240 min) was investigated. CNS response to the microwaves was evaluated as a function of food-reinforced conditioned motor reflexes. Statistical processing of the findings revealed that the time of formation of conditioned reflex activity as well as the specificity and dynamics of that activity are directly proportional to the intensity and duration of the irradiation. As the energy flux density was increased from 1 to 10 mwatt/cm^2, the CNS displayed an earlier, more persistent, and more distinct response, with the adaptive processes being supplanted by cumulative (the latent period of the response grew longer) due to the effect of microwave irradiation. A similar effect was observed on prolonging irradiation time from 15 to 240 min. When the intensity was increased while the duration remained the same, or vice versa, changes in the functional state of the higher divisions of the CNS were more pronounced and longer lasting. References 5: 4 Russian, 1 Polish.
[215-1386]

UDC 577.37

SOME APPROACHES TO THE MODELLING OF HEAT STRESS DURING MICROWAVE IRRADIATION

Moscow BIOFIZIKA in Russian Vol 25, No 1, Jan/Feb 80 pp 59-62 manuscript received 15 Sep 78

SHESTIPEROV, V. A. and TIKHONCHUK, V. S.

[Abstract] One of the more important characteristics of the interaction of microwaves with living objects is the conversion of the energy of electromagnetic field into heat, influenced by both physical and biological factors. A theoretical model, in which the time needed to reach lethal temperatures is related to the blood circulation cycle, has been analyzed. Experimental data showed that the developed model could be used to describe microwave heat stress and to determine the biophysical constants of heat regulation for the animal population under study. This model could also be used to analyze the effects of damage and recovery due to microwave irradiation of homoiothermic animals. The experimentally obtained data on temperature dynamics of white mice under hypodynamia and irradiation with microwaves agreed well with the theoretically calculated values. Figures 2; references 4: 1 Russian, 3 Western.
[266-7813]

UDC 616.1 / .14-005.6/.7- 2:613.1:550.38

ANALYSIS OF THE INCIDENCE AND OUTCOME OF ACUTE THROMBOSES AND EMBOLISMS OF PERIPHERAL VESSELS IN VARYING HELIOGEOMAGNETIC CIRCUMSTANCES

Moscow KARDIOLOGIYA in Russian No 2, 1980 pp 91-94 manuscript received 7 Jun 1979

KLIMOV, V. N., ROZHDESTVENSKAYA, Ye. D., MAKAROVA, N. P., and CHIRKOVA, L. A., Clinic for Hospital Surgery of the Treatment Department, Sverdlovsk Medical Institute

[Abstract] Data relating to 292 patients treated by the clinic from 1969-1978 were analyzed. The acute circulatory problems were divided about equally between thromboses and embolisms of arteries, and acute thromboses of deep veins of the extremities, and also, between men and women. These data were correlated with data on mild, moderate and severe magnetic storm activity. Results indicated that heliogeomagnetic factors comprised an additional burdening factor that brought complication of cardiovascular disorders. Such reactions occur invariably in the population, but may be serious and even lethal for those with various degrees of atherosclerosis. Figure 1; references: 13 Russian.
[283-12131]

UDC 616.24-006.6:08:615.847.8

MORPHOLOGIC EVALUATION OF PULMONARY CANCER REGRESSION INDUCED BY MAGNETOTHERAPY

Leningrad VOPROSY ONKOLOGII in Russian No 1, 1980 pp 28-34

OGORODNIKOVA, L. S., GAYRABED'YAN, N. G., RATNER, O. N., CHIRVINA, Ye. D., SIM, L. D., GARKAVI, L. Kh., KVAKINA, Ye. B., and UKOLOVA, M. A., Rostov Oncologic Scientific Research Institute, Rostov on Don

[Abstract] Morphologic studies on biopsies obtained during surgical treatment of 20 50-70 year old patients with various forms of lung cancer were used to evaluate the effects of preoperative magnetotherapy (7-30 3-20 min sessions of exposure to 100-250 oe variable magnetic field; 2 sessions/week). The results showed a decrease in tumor size in 7 patients, stabilization in 9 patients, and a moderate increase in the tumor size in 4 subjects. In the latter group the increase in the size of the tumor in 2 cases was due to proliferation of dense connective tissue. Histologic and ultrastructural examinations of the biopsy material showed that magnetotherapy induced foci of necrosis in the tumors, dystrophic changes, aberrations in nuclear chromatin, depression of the mitotic index, and an increase in the number of abnormal mitoses. The most favorable changes were seen in patients with well differentiated adenocarcinoma after 20-30 sessions of magnetotherapy. Figures 3; references 24: 5 Western, 19 Russian.
[277-12172]

UDC 615.849.112.015.4:[618.11-008.931+618.11-091.8]

CYTOENZYMATIC AND ULTRASTRUCTURAL FEATURES OF OVARIES EXPOSED TO WAVES IN THE CENTIMETER RANGE

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 1, 1980 pp 31-35

NIKOLOVA, L., and TAKEVA, Ts., Institute of Health Resort Science, Physiotherapy, and Rehabilitation, and Chair of Anatomy, Histology, and Embryology, Bulgarian Medical Academy, Sofia

[Abstract] Cytoenzymatic and ultrastructural studies were undertaken on the effects of 5 W centimeter waves on guinea pig ovaries in order to test the clinical impression that such therapy is without adverse consequences. Evaluation of the results showed that there were no ultrastructural changes indicative of damage. Furthermore, shortening of the diestrus phase (at the expense of proestrus and estrus phases) and elevation of certain enzyme activities (phosphatases, lactate dehydrogenase, steroid dehydrogenases) and an increase in the number of ribosomes indicated enhancement of ovarian function. These findings are in accord with favorable clinical outcomes of centimeter wave therapy in cases of infertility and inflammation of the female generative organs. Tables 1; figures 2; references 12: 3 Bulgarian, 4 Russian, 5 Western.
[253-12172]

UDC 616.712-007.24-085.847.8

CORRECTION OF INFUNDIBULIFORM THORACIC DEFORMITY BY MEANS OF PERMANENT SAMARIUM-COBALT MAGNETS

Moscow KHIRURGIYA in Russian No 3, 1980 pp 99-103

ISAKOV, Yu. F., and GERAS'KIN, V. I., professors, RUDAKOV, S. S., VASIL'YEV, G. S., candidate of medical sciences, GERBERG, A. N., candidate of technical sciences, BARINOV, G. M., MUKHO, B. B., KONDRASHIN, N. I., professor, and BESYADOVSKAYA, G. L., candidate of medical sciences, Pediatric Surgery Clinic, Scientific Research Laboratory of Clinical and Experimental Pediatric Surgery, Central Scientific Research Laboratory, 2nd Moscow Medical Institute imeni N. I. Pirogov

[Abstract] Data are presented on the correction of infundibuliform thoracic anomalies in 26 patients (24 in the 3-14 year age bracket) in whom a samarium-cobalt magnetic plate was positioned beneath the sternum to create, in conjunction with an external plate maintained in place by an orthopedic corset, a 1000 Oe permanent magnetic field to correctly position the sternum following thoracotomy. Magnet-mediated positioning was maintained for 28-45 days, followed by removal of the implanted plate 6 months after insertion through a vertical incision in the epigastric region. Excellent results were obtained in 24 of the patients and hypercorrection was noted in two subjects. Complications included right-sided hemothorax in 25 cases due to damage of the right costal pleura during thoracotomy, which was corrected by pleural punctures. There were no subjective or objective contraindications to this approach for correcting infundibuliform thoracic defects. Tables 2; figures 4; references 15: 5 Russian, 10 Western.
[295-12172]

UDC 616.37-002.1-085.849.11

COMPREHENSIVE CONSERVATIVE TREATMENT OF ACUTE PANCREATITIS USING CONSTANT MAGNETIC FIELDS

Moscow SOVETSKAYA MEDITSINA in Russian No 2, 1980 pp 34-38 manuscript received 29 Jan 1979

VALTER, E. O., Department of Hospital Surgery, Izhevsk Medical Institute

[Abstract] In the laboratory test bile was injected to induce acute pancreatitis in 25 dogs, then 20 were treated using constant magnetic fields while 5 were reserved as control animals. Quantities of amilase, trypsin and trypsin inhibitors were monitored in both test and control animals. The success of the procedure on dogs led to constant magnetic field treatments for human patients with acute pancreatitis, and the various procedures combined with this experimental approach are described. Although the effects of the comprehensive treatment varied, the results indicated that the application of constant magnetic field therapy both to skin areas above internal organs and to areas related to the pancreas improved the effects of treatment. Tables 2; references 13: 11 Russian, 2 Western.
[284-12131]

UDC 616.5-036.12-085.846

THE EFFECT OF MICROWAVES IN THE CENTIMETRIC RANGE ON THE COURSE OF CERTAIN CHRONIC DERMATOSES

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 6, 1979 pp 50-56 manuscript received 6 Jul 79

NIKOLAYEVA, V. V., Department of Physiotherapy and Therapeutic Exercise (K. A. Anan'yeva, doctor of medical sciences, director) and the Clinic for Skin Diseases (Professor G. F. Romalenko, director), Moscow Scientific Research Institute of Clinical Medicine imeni M. F. Vladimirskiy

[Abstract] The use of microwaves in the centimetric range represents one of the newer approaches to the treatment of chronic skin diseases such as eczema, disseminated and focal neurodermatitis, prurigo and lichen planus erythematosus. Because of the recognized intractability of these disorders, current theories that they are of a combined neurogenic, endocrine and allergenic nature and because of the probability of allergic reactions to standard medical treatment, investigators are now looking to physical methods of treatment. Centimeter waves are known to have an anti-inflammatory and desensitizing effect coupled with a normalizing and stimulative action on the central and vegetative nervous system while acting to restore neuroendocrine regulation within the body. The centimeter wave range is preferable to the high- or ultra-high frequency ranges because of its conduciveness to precise dosage administration, its potential for localized action and the intensive absorption of its energy by biological tissue.

The objective of this study was to determine the medical effectiveness of centimeter wave therapy for patients with eczema, neurodermatitis, prurigo and lichen planus, to investigate the mechanics of how this treatment works, to develop techniques of treatment and to learn the indications and contraindications for its use. A total of 203 persons suffering from these disorders for periods of from one to 36 years were involved in the study. Slightly less than half these individuals were treated primarily with centimeter microwaves while the remainder received wave therapy in conjunction with vitamins, antihistamines and sedatives. All were given topical medications for symptomatic relief as needed and none were given internal or externally applied hormonal medications.

Prior to beginning therapy, the functional status of the adrenal cortex, electrolyte balance and the sympatho-adrenal system was determined for these patients through a battery of blood and urine tests and dysfunctions were established in many. The vast majority of these patients demonstrated clinical improvement or complete reversal of symptoms following a series of treatments. Most displayed good tolerance to centimeter wave therapy although a few experienced itching or local hyperemia. Combining wave therapy with the use of antihistamines, desensitizing drugs and vitamins

improved results somewhat. Over a follow-up period of 1 to 3 1/2 years, one third of the patients experienced no recurrences or exacerbations while about one half had relatively mild recurrences or flare-ups. The centimeter wave therapy also produced improvement in the indicators of the functional state of the adrenal cortex, electrolyte balance and sympatho-adrenal system as reflected in blood and urine tests.

The good results, ease of implementing the procedure for in- and out-patients favor the use of centimeter wave therapy when indicated by symptoms of ec-zema, neurodermatitis, lichen planus or prurigo. Contraindications to the use of centimeter wave therapy include secondary erythroderma, accompanying staphylococcal or streptococcal skin infections with manifestations of lymphadenitis or lymphangina, edema or oozing at the radiation site. Ten to twelve treatments lasting four to ten minutes each with a progressive increase in power from 4-10 Watts were deemed to constitute a complete course of therapy. Tables 3; references 12: 10 Russian, 2 Western.
[190-9003]

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